REMARKS

I. Introduction

By the present Amendment, 1 and 18-20 have been amended. No claims have been added or cancelled. Accordingly, claims 1-6, 8-10, and 18-20 remain pending in the application. Claims 1 and 18 are independent.

II. Office Action Summary

In the Office Action of June 9, 2010, claims 19 and 20 were rejected under 35 USC §112, second paragraph, as being indefinite. Claims 1-6, 8, and 18-20 were rejected under 35 USC §103(a) as being unpatentable over U.S. Patent No. 6,045,508 issued to Hossack et al. ("Hossack") in view of U.S. Patent No. 6,263,089 issued to Otsuka et al. ("Otsuka"). Claims 9 and 10 were rejected under 35 USC §103(a) as being unpatentable over Hossack in view of Otsuka, and further in view of U.S. Patent No. 4,932,414 issued to Coleman et al. ("Coleman"). These rejections are respectfully traversed.

III. Rejection under 35 USC §112

Claims 19 and 20 were rejected under 35 USC §112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter regarded as the invention. Regarding this rejection, the Office Action indicates that it is not clear when a correlation is "mutual" and how the motion of the projected component is produced if the motion is lower than a predetermined value.

By the present Amendment, Applicants have amended the claims to better define the invention and address the issues of indefiniteness raised in the Office Action. For example, reference to calculation of a "mutual" correlation function has

been eliminated. Applicants note that the motion of the projected object is produced by calculating a correlation function between a base frame and a next frame in a sequence. If the motion is lower than a predetermined value, however, motion of the projected component is produced by calculating the correlation function between the base frame and a frame which occurs after the next frame (i.e., the second subsequent frame) in the sequence of frames. Furthermore, as discussed in the Specification, if the motion between the adjacent frames is smaller than the detection sensitivity resulting from the correlation function, then the motion estimation due to the correlation function between the adjacent frames will always be zero. Thus, according to one exemplary embodiment of the invention, it would be possible to detect zero in such a case if the motion is lower than a predetermined value. As illustrated in Fig. 14, this would allow the process to proceed to the subsequent step of calculating the correlating function with the second subsequent (after next) frame. See paragraphs [0068] - [0070] of the Published Application.

Based on the foregoing, it is respectfully submitted that the presently pending claims satisfy the requirements of 35 USC §112, second paragraph. Withdrawal of this rejection is therefore respectfully requested.

IV. Rejection under 35 USC §103

Claims 1-6, 8, and 18-20 were rejected under 35 USC §103(a) as being unpatentable over Hossack in view of Otsuka. Regarding this rejection, the Office Action asserts that Hossack discloses an ultrasonic probe system and method for acquiring two-dimensional image information and relative positional information to allow subsequent three-dimensional reconstruction utilizing an ultrasonic probe which has at least two transducer arrays made of piezoelectric material. The Office

Action indicates that Hossack discloses a first ultrasound array to acquire first two-dimensional image data, a second ultrasound array to acquire a second two-dimensional data, multiple two-dimensional image data being accumulated and assembled into a three-dimensional volume, and reconstruction of three-dimensional images. The Office Action further asserts that Hossack discloses a motion estimator which receives image data from both transducer arrays and is capable of estimating/detecting a three-dimensional motion of the object from the reflection signals, and simultaneously displaying images from both transducer arrays in a split screen.

The Office Action admits that Hossack fails to specifically mention producing velocity components of the three-dimensional motion. The Office Action indicates, however, that Hossack suggests using Doppler energy which is well known in the art for detecting velocity components. Otsuka is relied upon for teaching determination of velocity components of three-dimensional motion of an object. The Office Action concludes that it would have been obvious to combine the teachings of Hossack with those of Otsuka by determining or producing velocity components of the three-dimensional motion of an object for analysis purposes. Applicants respectfully disagree.

As amended, independent claim 1 defines an ultrasonic motion detecting device that comprises:

> first and second ultrasonic transducers having piezoelectric elements arranged in an array, which transmit ultrasonic waves to an object and acquire reflection signals from the object;
>
> a motion detection unit that extracts an estimation region which is used for estimating a motion of the object from the reflection signals that are acquired by the first and second ultrasonic transducers, and detects a three-dimensional motion of the object within the estimation region; and

an image display unit that displays the three-dimensional motion within the estimation region,

wherein ultrasonic wave scanning surfaces due to the first and second ultrasonic transducers cross over each other, and

wherein the motion detection unit detects projected components that are detected from a plurality of first two-dimensional cross-section images of the object which are obtained from the first ultrasonic transducer and a plurality of second two-dimensional cross-section images of the object which are obtained from the second ultrasonic transducer to produce velocity components of the three-dimensional motion of the object, which is positioned on an intersection line of the first and second two-dimensional cross-section images and constructs the three-dimensional motion on the basis of the first two-dimensional cross-section image, the second two-dimensional cross-section image and the projected components.

The ultrasonic motion detecting device of independent claim 1 includes first and second ultrasonic transducers having piezoelectric elements arranged in an array in order to transmit ultrasonic waves to an object and acquire reflection signals from the object. The device includes a motion detector unit which extracts an estimation region that is used for estimating the motion of the object from the reflection signals acquired by the first and second ultrasonic transducers, and detects a three-dimensional motion of the object within the estimation region. An image display is also provided for displaying the three-dimensional motion within the estimation region. The ultrasonic motion detection device is configured such that ultrasonic wave scanning surfaces resulting from the first and second ultrasonic transducers cross over each other. Additionally, the motion detection unit detects projected components that are detected from a plurality of first-dimensional cross section images of the object obtained from the first ultrasonic transducer and the plurality of second two-dimensional cross section images of the object obtained from the second ultrasonic transducer. The motion detection unit subsequently produces

velocity components of the three-dimensional motion of the object, which is positioned on an intersection line of the first and second two-dimensional cross section images, and further constructs the three-dimensional motion based on the first two-dimensional cross section image, the second two-dimensional cross section image, and the projected components.

According to the invention defined by independent claim 1, spatial position variations are detected by processing two-dimensional signals. Furthermore, two intersecting bi-plane images are detected using a pair of ultrasonic transducers. See paragraph [0054] of the published application and Fig. 2. The three-dimensional velocity components of the motion of the object which are positioned on the intersection line of the bi-plane images are obtained in order to estimate the motion. Thus, velocity components that are projected onto the two planes are detected on the bi-plane images. See paragraph [0062]. More particularly, a plurality of vector detection points (or regions) are set on the intersection line of the bi-plane images, the vector detections are respectively executed in the bi-plane images, and a three-dimensional vector is synthesized using two independent vectors having the same base point. Accordingly, it becomes possible to obtain three-dimensional vector detection with improved accuracy, and detect different movements of the object on the intersection line.

As further discussed in the Specification, this allows calculation of the mutual correlation function between adjacent frames, thereby making it possible to detect a difference in the motion which depends on the angle between the direction of the motion and the imaging region. The slope corresponding to the velocity components is also quantitatively estimated so that the three-dimensional motion can be estimated. Additionally, when plural regions in which the motion is estimated are set,

the partial motion of the object can be estimated. Accordingly, it becomes possible to additionally estimate the deformation of the object. See paragraphs [0064] and [0065], and Figs. 3-5.

The Office Action alleges that that combination of Hossack and Otsuka discloses all of the features recited in independent claim 1. Applicants' review of these references, however, suggests otherwise. Hossack discloses an ultrasonic probe which includes at least two ultrasonic arrays and allows construction of three-dimensional images of the region examined by the probe. According to Hossack, two-dimensional images are sequentially obtained from each array (20, 22) which contains the arrays in a scanning direction. Array 22 is used as an imaging array to allow formation of three-dimensional images by spatially arranging data from array 22 in the scanning direction. Array 20 is used as a tracking array and detects motion of the probe in the scanning direction. Data from arrays 20 and 22 are respectively stored in a tracking array data storage and an image data storage. See column 5, lines 7-23 and Fig. 4. Since it is necessary to arrange a plurality of images having a constant spatial interval in the moving direction in order to construct the three-dimensional images, the image data from the image data storage is based on data from the tracking array data storage. Since array 20 is only used for a function of the tracking plane, it never intersects with array 22. Thus, it is not possible to estimate motion of the object based on the intersection line of the first and second two-dimensional cross section images.

Otsuka discloses a system for extracting image features from an image sequence in which frames are sequentially arranged with respect to time. The system includes a unit for inputting the image sequence, a unit for acquiring a motion trajectory of an image contour of a target included within a region in the input image

sequence, a unit for acquiring a plane histogram of a tangent plane to the motion trajectory and partial planes which may be included in the motion directory, and a unit for measuring temporal features of the image from the acquired plane histogram. According to Otsuka, however, three-dimensional volume data is obtained by forming difference images among the frames that are arranged in time sequence, in stacking the formed difference images. Otsuka never discusses the use of a bi-plane structure, and consequently, is incapable of obtaining the velocity components of the three-dimensional motion of the object based on the intersection line of the first and second two-dimensional cross section images. Accordingly, the combination of Hossack and Otsuka fails to provide any disclosure or suggestion for features recited in independent claim 1 such as:

> wherein the motion detection unit detects projected components that are detected from a plurality of first two-dimensional cross-section images of the object which are obtained from the first ultrasonic transducer and a plurality of second two-dimensional cross-section images of the object which are obtained from the second ultrasonic transducer to produce velocity components of the three-dimensional motion of the object, which is positioned on an intersection line of the first and second two-dimensional cross-section images and constructs the three-dimensional motion on the basis of the first two-dimensional cross-section image, the second two-dimensional cross-section image and the projected components.

It is therefore respectfully submitted that independent claim 1 is allowable over the art of record.

Claims 2-6, 8-10, and 19 depend from independent claim 1, and are therefore believed allowable for at least the reasons set forth above with respect to independent claim 1. In addition, these claims each introduce novel elements that independently render them patentable over the art of record.

As amended, independent claim 18 defines an ultrasonic motion detecting device that comprises:

> first and second ultrasonic transducers, which transmit ultrasonic waves to an object and acquire reflection signals from the object; and
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> a motion detection unit that extracts an estimation region which is used for estimating a motion of the object from the reflection signals that are acquired by the first and second ultrasonic transducers, and detects a three-dimensional motion of the object within the estimation region;
>
> wherein ultrasonic wave scanning surfaces due to the first and second ultrasonic transducers cross over each other, and
>
> wherein the motion detection unit detects velocity components of the three-dimensional motion of the object, which is positioned on an intersection line of the ultrasonic waves scanning surfaces, based first two-dimensional cross-section images of the object obtained from the first ultrasonic transducer in sequential frames and second two-dimensional cross-section images of the object obtained from the second ultrasonic transducer in sequential frames, and constructs the three-dimensional motion of the object to be displayed in an image display unit in accordance with the velocity components of the three-dimensional motion of the object.

Independent claim 18 has been amended to incorporate features similar to those now recited in independent claim 1. In particular, independent claim 18 specifies that the motion detection unit detects velocity components of the three-dimensional motion of the object which is positioned on an intersection line of the ultrasonic waves scanning surfaces, based on first two-dimensional cross section images of the object obtained from the first ultrasonic transducer in sequential frames, and second two-dimensional cross section images of the object obtained from the second ultrasonic transducer in sequential frames. The three-dimensional motion of the object is subsequently constructed to be displayed in an image display unit in accordance with the velocity components of the three-dimensional motion of

the object. As previously discussed with respect to independent claim 1, the cited references fail to provide any disclosure or suggestion for such features.

It is therefore respectfully submitted that independent claim 18 is allowable over the art of record.

Claim 20 depends from independent claim 18, and is therefore believed allowable for at least the reasons set forth above with respect to independent claim 18. In addition, this claim introduces novel elements that independently render it patentable over the art of record.

V. Conclusion

For the reasons stated above, it is respectfully submitted that all of the pending claims are now in condition for allowance. Therefore, the issuance of a Notice of Allowance is believed in order, and courteously solicited.

If the Examiner believes that there are any matters which can be resolved by way of either a personal or telephone interview, the Examiner is invited to contact Applicants' undersigned attorney at the number indicated below.

AUTHORIZATION

Applicants request any shortage or excess in fees in connection with the filing of this paper, including extension of time fees, and for which no other form of payment is offered, be charged or credited to Deposit Account No. 01-2135 (Case: 520.46263X00).

Respectfully submitted,
ANTONELLI, TERRY, STOUT & KRAUS, LLP.

/Leonid D. Thenor/
Leonid D. Thenor
Registration No. 39,397

LDT/vvr
1300 N. Seventeenth Street
Suite 1800
Arlington, Virginia 22209
Tel: 703-312-6600
Fax: 703-312-6666

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